USB

Universal Serial Bus

Basic Architecture

Host-to-Device Connections and Transactions
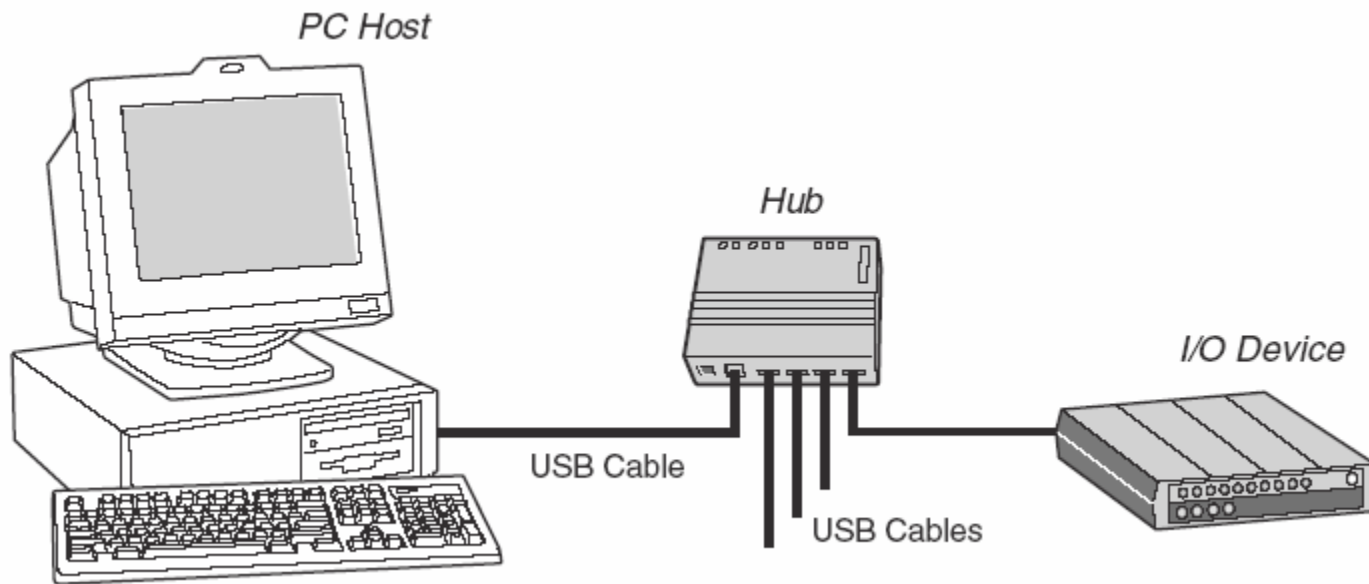
Features

- Asynchronous serial communication.
- Attachment is detected and device is configured automatically.
- Single standard connector.
- 127 devices can be connected via hubs.
- Three device speeds:
  - Low (1.5Mb/s)
  - Full (12Mb/s)
  - High (480Mb/s)
- Power: 5V, 100mA-500mA
- Error detection/recovery is automatic.

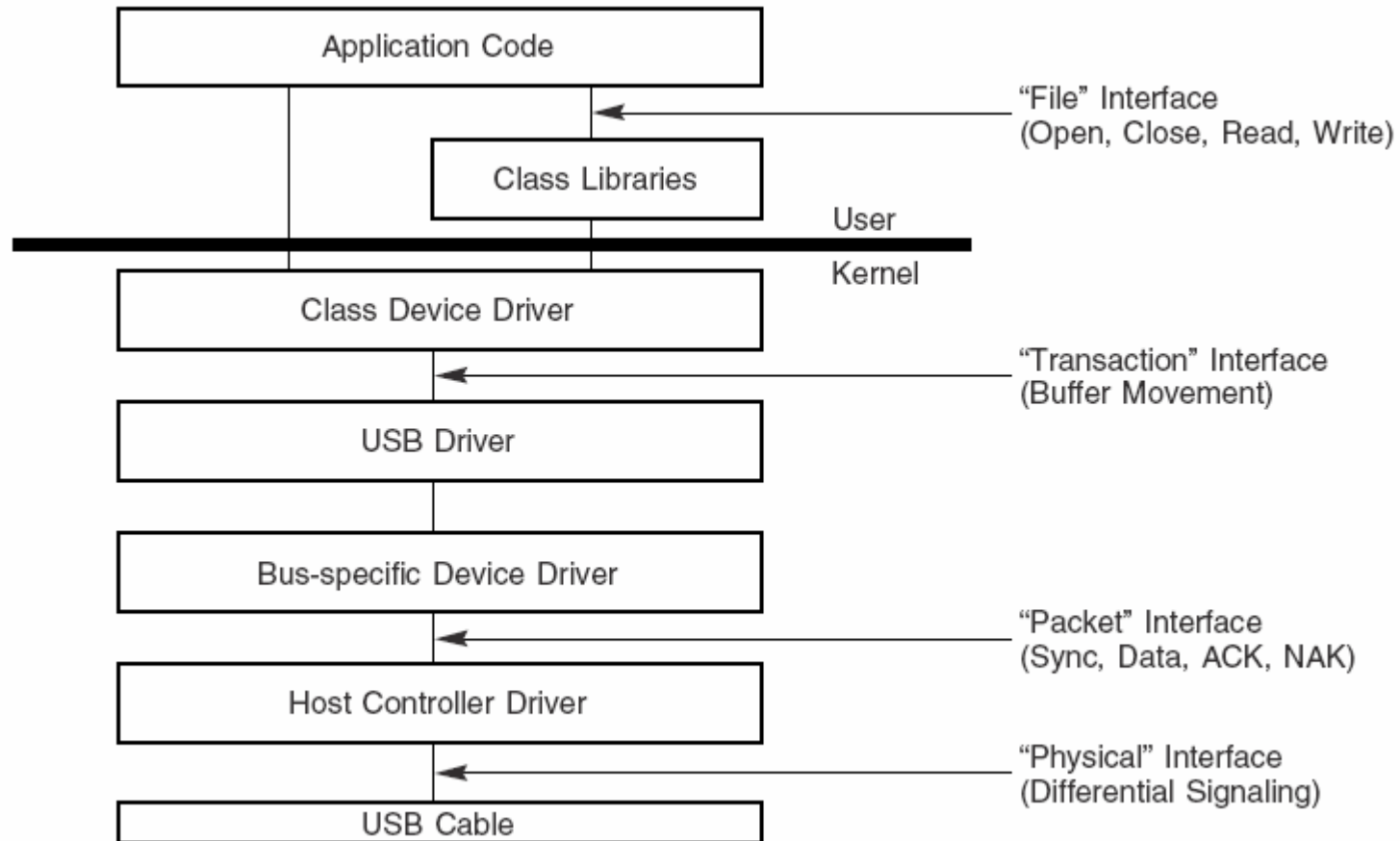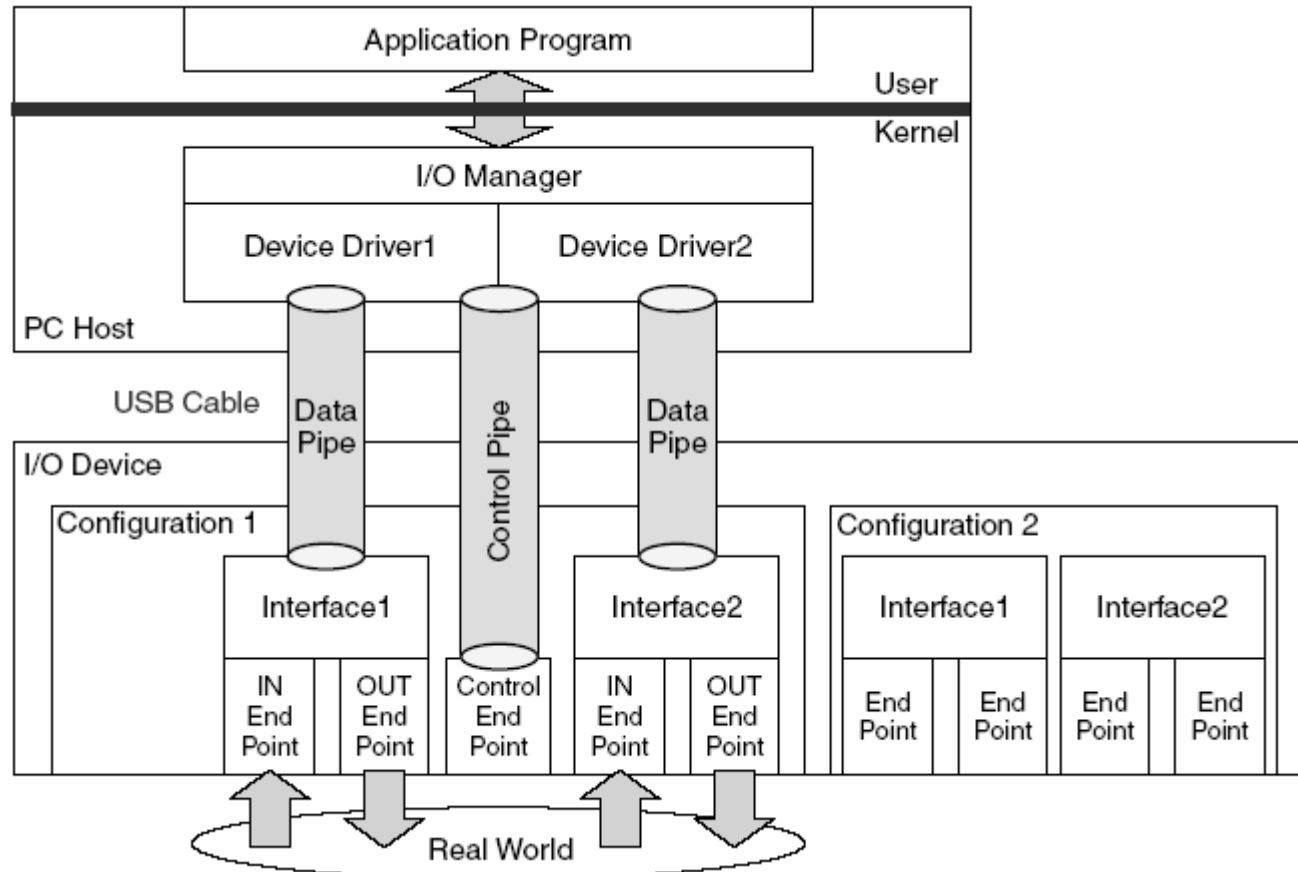# Terminology

PC Host Software
(USB Communication Flow)

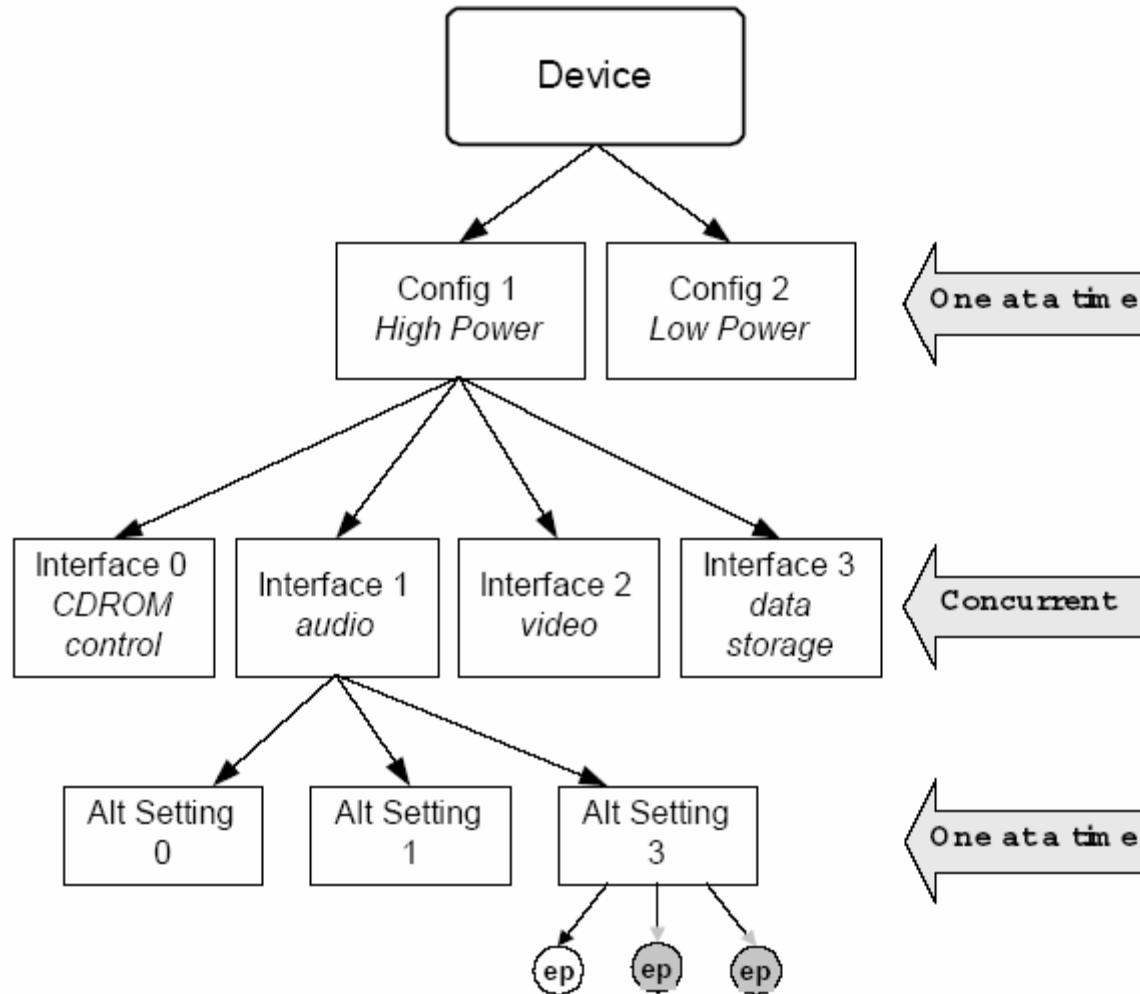|	
Application Code	
	"File" Interface (Open, Close, Read, Write)
Class Libraries	User
	Kernel
Class Device Driver	
	"Transaction" Interface (Buffer Movement)
USB Driver	
Bus-specific Device Driver	
	"Packet" Interface (Sync, Data, ACK, NAK)
Host Controller Driver	
	"Physical" Interface (Differential Signaling)
USB Cable	

I/O Device

Multiple Personalities

Enumeration

- When a device is attached, the OS "enumerates" the device, identifies its driver, and assigns an address to it.
- In the numeration process, data structures (transfer descriptors) contain information needed by the host to generate transactions. This information includes:
  - USB device address.
  - Type of transfer.
  - Direction of transfer (write or read).
  - Transfer size (# of bytes).
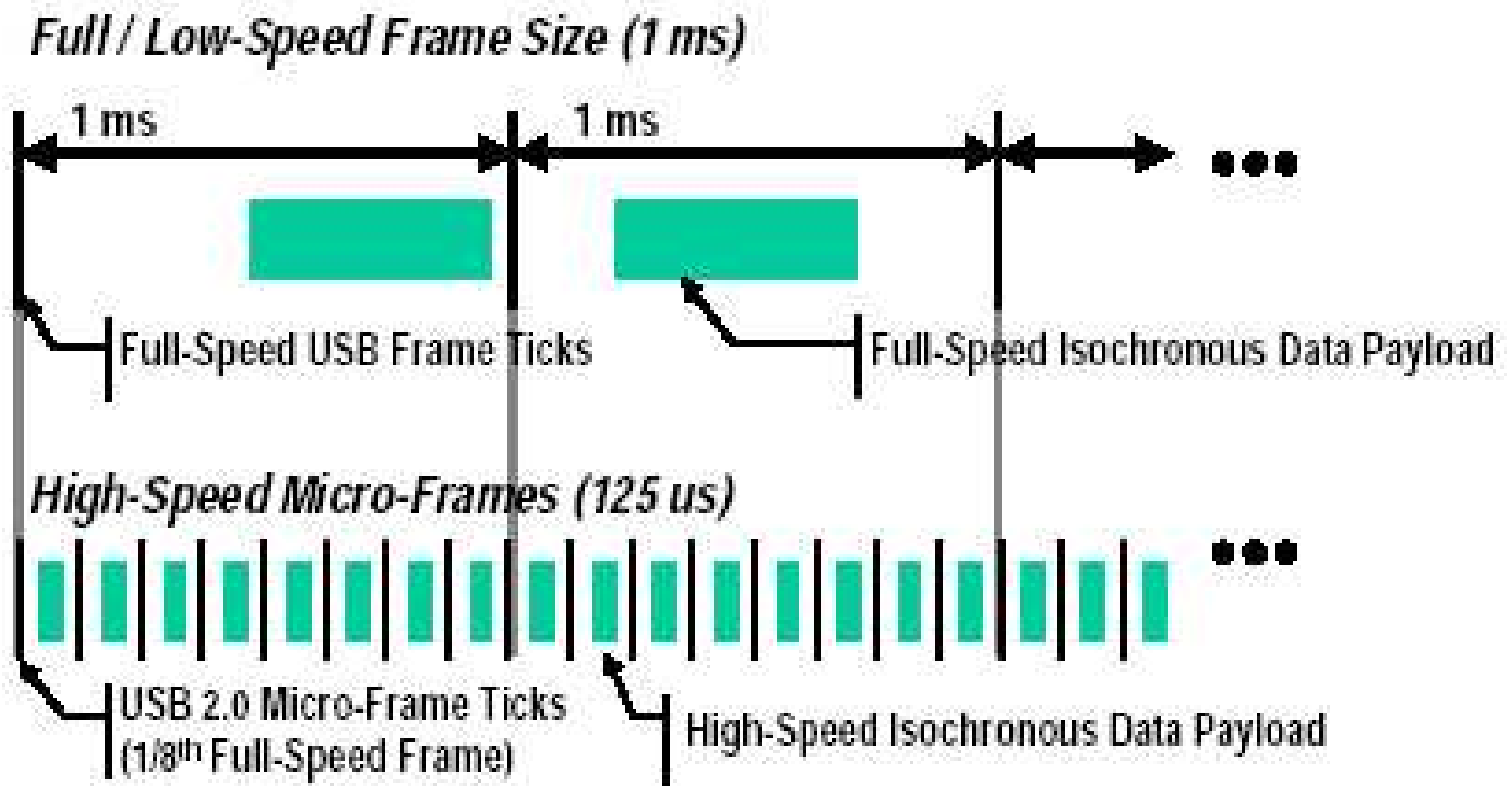 - Speed.
  - Address of the device driver's memory buffer.

Enumeration Steps

n Getting the device descriptor.

n Setting an address.

n Getting the device descriptor again.

n Getting the configuration descriptor.

n Selecting the device driver.

n Setting the configuration.

Frames

Full / Low-Speed Frame Size (1 ms)

1 ms   1 ms

Full-Speed USB Frame Ticks   Full-Speed Isochronous Data Payload

High-Speed Micro-Frames (125 us)

USB 2.0 Micro-Frame Ticks
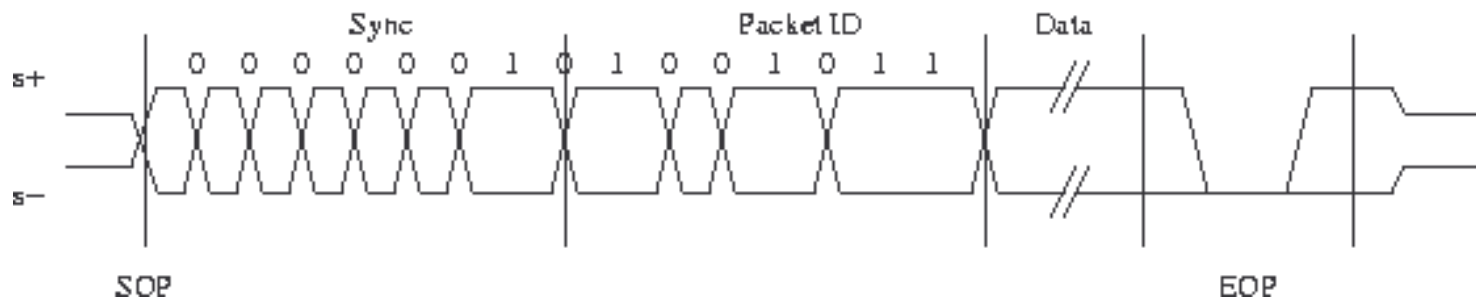(1/8th Full-Speed Frame)   High-Speed Isochronous Data Payload

The Fundamental Packet

n All communications on the USB are organized into small packets.

n Four types of packets:

   n Token, Data, Handshake, and Special.

n Each packets consists of 3 parts:

   n Start (SYNC), information and end.
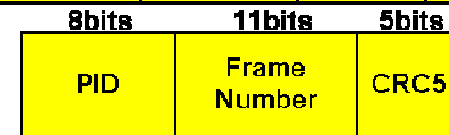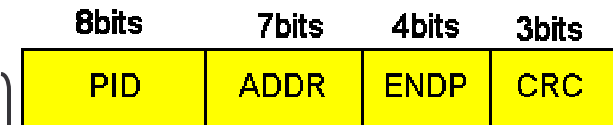
Packet Types

Group	PID Value	Packet Identifier
Token	0001	OUT Token
	1001	IN Token
	0101	SOF Token
	1101	SETUP Token
Data	0011	DATA0
	1011	DATA1
	0111	DATA2
	1111	MDATA
Handshake	0010	ACK Handshake
	1010	NAK Handshake
	1110	STALL Handshake
	0110	NYET (No Response Yet)
Special	1100	PREamble
	1100	ERR
	1000	Split
	0100	Ping

8bits	7bits	4bits	3bits
PID	ADDR	ENDP	CRC

8bits	11bits	5bits
PID	Frame Number	CRC5

8bits	0-1023bits	16bits
PID	Data	CRC16

8 bits

PID

Four Transaction Types

Type	Important attributes	Max size LS	Max size FS	Max size HS	Examples
Interrupt	Quality + time	8	64	3072	Mouse, keyboard
Bulk	Quality	-	64	512	Printer, scanner
Isochronous	time	-	1023	3072	Audio, video
Control	Quality + time	8	64	64	System control

Interrupt Transfer

HOST

DEVICE

Interrupt OUT Transfer
- OUT token →
- DATA →
- ACK/NAK/STALL ←

Interrupt IN Transfer
- IN token →
- DATA ←
- ACK →

Isochronous Transfer

Control Transfer